

approximating an illumination effect of each of the finite light sources by the use of a single point light source of varying intensity and location, taking into account the finite size and center of each of the finite light sources.

REMARKS

The Office Action dated June 20, 2000 has been received and carefully noted. The above amendment and the following remarks are submitted as a full and complete response thereto. Claims 1 has been amended to more particularly point out and distinctly claim the present invention. No new matter has been added. Claims 1-10 are respectfully submitted for consideration.

Applicant wishes to thank the Examiner for indicating the allowance of claims 7-10. Applicant also wishes to thank the Examiner for conducting a telephone interview with Applicant's representative interview on July 11, 2001. The discussions were helpful and Applicant submits the amended claim 1 in view of that discussion.

Claims 1-6 remain rejected under 35 U.S.C. §103(a) as being unpatentable over *Nishita et al.* ("Continuous Tone Representation of Three-Dimensional Objects Illuminated by Sky Light", Computer Graphics, Vol. 20, No. 4, August 1986) in view Persistence of Vision®'s Ray-Tracer software ("POV-Ray", 1997). The above rejection is respectfully traversed based on the remarks that follow.

The present invention has been discussed at length in Applicant's prior Responses, and need not be repeated. *Nishita et al* is directed to modeling of natural light, that considers both direct sunlight and scattered ambient light. The "skylight" is modeled as a hemisphere with a large radius. The hemisphere is subdivided into bands and the light intensity of individual bands is calculated, based on a single line within that

band. Applicant notes that the reference defines that the intensity within the band is uniform. While there is a discussion of the use of a line to approximate a band of the "sky," there is no discussion of a point light source or the use of a point light source. The Examiner has acknowledged this deficiency.

The POV-Ray reference is directed to software used to create three-dimensional, photo-realistic images using a rendering technique called ray-tracing. The program description section of the documentation, not cited by the Office Action, provides further description of the software. "It [The program] reads in a text file containing information describing the objects and lighting in a scene and generates an image of that scene from the view point of a camera also described in the text file. *Ray-tracing is not a fast process by any means*, but it produces very high quality images with realistic reflections, shading, perspective and other effects." {emphasis added}

The POV-Ray reference is, in fact, a good example of a prior art system that creates the type of soft light transition effect produced by the spherical pseudo area light. It is a brute force, calculation intensive method that makes no attempt at the cognitive leap necessary to reduce or eliminate its computational cost.

Claim 1 previously recited, in part, "approximating an illumination effect of each of the finite light sources *by the use of a single point light source*." Applicant asserts that *Nishita et al.* does not teach or suggest taking into account the illumination effect of each of the finite light sources through the use of a single point light source. *Nishita et al.* uses regular slices or bands of the hemisphere and there is no appreciation for the use of point light sources. In fact, the Office Action acknowledges that *Nishita et al.* fails to positively disclose the use of point light sources.

The addition of the POV-Ray reference does not provide such a disclosure. If point light sources were used in *Nishita et al.*, such a point light would be fixed and constant. The bands and/or lines, disclosed in *Nishita et al.*, have a constant intensity and there is no discussion in either reference of having the light source be varied to approximate the illumination effect of a finite light source.

In the methods of the present invention, the point light is not fixed and constant, but varies in location, intensity, color, and other characteristics as a function of the surface orientation that is being illuminated. It's the point light's variability as a function of the surface orientation that makes this method unique and allows it to produce the results it does. The cited references, taken alone or in combination, fail to teach this aspect of the invention.

Additionally, claim 1 recites, in part, in the approximating step, "taking into account the finite size and center of each of the finite light sources." *Nishita et al.* does not teach or suggest taking into account the size or position of the "finite light source." *Nishita et al.* uses regular slices or bands of the hemisphere and there is no appreciation for the approximation of light sources of definite size. In fact, *Nishita et al.* asserts, in many places, that the dome providing the sky light has a very large radius. The calculations in *Nishita et al.* do not take into account the size of the dome because it is not important to the purpose of the reference, which to approximate skylight. Thus, Applicant respectfully asserts that *Nishita et al.* teaches away from considering the size and position of a light source. The POV-Ray reference also fails to teach taking the size of a finite light source into account. Given the lack of disclosure, Applicant respectfully

asserts that the claim 1, and claims dependent thereon, would not have been obvious in view of the *Nishita et al.* and the POV-Ray reference.

Applicants acknowledge that using a set of point lights to approximate the effect of an area light source is generally known in the art. It is covered in most commercial rendering systems and computer graphics textbooks. If the Examiner wishes to assert that a line, made up of a series of point light sources, can be used to approximate the illumination effect of a finite light source and that such a construction was known in the art, Applicant would not generally disagree. However, the use of *Nishita et al.* and POV-Ray to approximate an area light source by a set of many point lights, while known, is irrelevant to a discussion of the present claims. As discussed above, that is not what has been disclosed or claimed.

Additionally, such a configuration does not render the present invention obvious. One reason why the configuration of a single point light source and a set of point light sources are not equivalent is that the computational cost, which is at the core of this patent and of computer graphics as a whole, is not equivalent. Because the cost of computing a computer graphic scene is directly proportional to the number of light/surface-point interaction calculations that must be done, the use of lots of point lights to produce an effect, where each point light requires a separate light/surface interaction calculation, is a lot more expensive than doing one light/surface calculation.

For example, if one needs 10 point lights to approximate the effect of one area light (which is entirely reasonable), then that will require 10 times more computation than will be done using a single point light to approximate the effect - as is done in the present invention. Since every light/surface calculation is very expensive, any means of

reducing or eliminating those calculations is of the utmost importance. Similarly, increasing the number of these calculations, as proposed in POV-Ray or combining *Nishita et al.* with POV-Ray is diametrically opposed to what this invention is about and misses the point completely.

While the Office may allege that a set of lights is equivalent to one light that varies, the implication of those semantics is not readily implementable: every light requires a separate light/surface interaction calculation. Additionally, this is not simply a question of implementation. The use of many point lights to approximate an area light effect requires that all the point-light/surface interaction calculations be done - otherwise the desired effect is not produced.

In addition, the rejection fails to consider or overcome the indicia of nonobviousness provided in the specification and discussed in Applicant's previous response. When evidence of any secondary considerations is submitted, the Examiner must evaluate the evidence. M.P.E.P. 2141.

The rejection alleges, in effect, that the POV-Ray software, coupled with *Nishita et al.*, can approximate the effect of any type of area light source and that such approximation is an obvious extension of *Nishita et al.* However, if such an extension were obvious, it would be in widespread use throughout the industry. This is due to the fact that the cost of implementing a spherical pseudo area light is virtually nil, and the effect is much more realistic illumination. The pursuit of realism and lower computational cost are the two dominant driving forces in the industry. The fact that such an implementation, which addresses both these goals, does not exist is a clear demonstration that such an extension is not obvious.

In addition, even if the references were somehow combined, they would not reduce computation time nor cost. As discussed above, the POV-Ray software teaches away from efficiency and instead emphasizes photo-realistic results. The combination of references cited in the rejection would not provide the benefits of the present invention. The Examiner is respectfully requested to consider the above noted benefits in reconsidering the prior rejections.

As such, Applicant respectfully asserts that the rejection of claims 1-6 is improper and should be withdrawn. Applicant also respectfully requests that the application be allowed to proceed to issue. If for any reason the Examiner determines that the application is not now in condition for allowance, it is respectfully requested that the Examiner contact, by telephone, the Applicant's undersigned attorney at the indicated telephone to arrange for an interview to expedite this position of this application.

In the event this paper is not being timely filed, the Applicants respectfully petition for an appropriate extension of time. Any fees for such an extension together with any additional fees may be charged to counsel's Deposit Account No. 01-2300.

Respectfully submitted,

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MARKED UP COPY OF REWRITTEN MATERIAL

1. (Three Times Amended) A method for illuminating surfaces in computer graphics comprising the steps of:

constructing a plurality of finite light sources within a computer animated scene, each of the finite light sources having a finite size and a center;

constructing a plurality of surfaces within the scene, each surface consisting of a plurality of points; and

approximating an illumination effect of each [all] of the finite light sources by the use of a single point light source of varying intensity and location, taking into account the finite size and center of each of the finite light sources.